IS 10624 (1983): High voltage fuse-links for motor circuit applications [ETD 39: Fuses]

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IS : 10624 - 1983
(Reaffirmed 2001)

Indian Standard
SPECIFICATION FOR HIGH VOLTAGE FUSE LINKS FOR MOTOR CIRCUIT APPLICATIONS

(Third Reprint MAY 1997)

UDC 621.316.923.027.3 : 621.313.13

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Gr 3 *September* 1983

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SPECIFICATION FOR HIGH VOLTAGE FUSE LINKS FOR MOTOR CIRCUIT APPLICATIONS

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Indian Standard

SPECIFICATION FOR HIGH VOLTAGE FUSE LINKS FOR MOTOR CIRCUIT APPLICATIONS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 25 July 1983, after the draft finalized by the High Voltage Switchgear and Controlgear Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 Three classes of high voltage fuses are in general use, namely, the expulsion, liquid and high rupturing capacity cartridge types. The most common application is on distribution systems up to 33 kV, while the liquid and cartridge type fuses are available for use on systems up to 132 kV, used largely for protecting voltage transformers.

0.3 The following Indian Standards are available on high voltage fuses:

IS : 9385 Specification for high voltage fuses

- (Part 1)-1979 Current limiting fuses
- (Part 2)-1980 Expulsion fuses and similar fuses
- (Part 3)-1980 Application guide for high voltage fuses.

While Parts 1 and 2 of this series cover the requirements and methods of tests for the two types of high voltage fuses, Part 3 covers guidelines on the application, operation and maintenance, as an aid in obtaining satisfactory performance with high voltage fuses.

0.4 While Part 3 of the IS mentioned in **0.3** is in itself comprehensive enough to provide guidelines on the parameters to be accounted for in the selection of fuse-links, it is felt essential to bring out a separate standard giving additional requirements for fuse-links intended to withstand specific service requirements encountered in special uses such as in the protection of motors or cables The object of the present standard is therefore to standardize the time-current characteristics to cover additional pulse withstand requirements regarding testing and to give guidance regarding selection of fuse-links specifically intended for use in motor circuits.

0.5 Although in principle any high voltage fuse-link can be used to protect motor circuits, there are advantages in selecting a device specifically designed for the application. This standard is intended to standardize the parameters to be declared for such specific uses.

0.6 In the preparation of this standard, considerable assistance has been derived from IEC Pub 644 (1979) 'Specification for high voltage fuse-links for motor-circuit applications', issued by the International Electrotechnical Commission.

0.7 This standard corresponds appreciably with the IEC Publication referred to in **0.6** and there are no major differences.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard applies primarily to fuse-links used with motors, started direct-on-line on alternating current systems of 50 Hz.

NOTE — When motors are used with assisted starting, this specification can also be applied but particular attention should be paid to the selection of the rated current of the fuse-link (*see* **8.1**) and the manufacturer of the fuse-link should preferably be consulted.

1.2 Fuse-links according to this specification are intended to withstand normal service conditions and motor starting pulses. They shall comply with the requirements of IS : 9385 (Part 1)-1979†.

2. TERMINOLOGY

2.1 For the purpose of this standard the definition given in IS : 9385 (Part 1)-1979† shall apply.

3. FUSE-LINK TIME-CURRENT CHARACTERISTICS

3.1 Relatively high operating current (slow operation) is desirable in the 10 second region of the pre-arcing time-current characteristic, to give maximum withstand against motor starting current.

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*Rules for rounding off numerical values (*revised*).

†Specification for high voltage fuses: Part 1 Current limiting fuses.

Relatively low operating current (fast operation) is desirable in the region below 0·1 second to give maximum short-circuit protection to associated switching devices, cables and motors and their terminal boxes.

3.2 The pre-arcing time-current characteristics of fuse-links for motor circuit applications shall be within the following limits:

$I_{f10}/I_n \geqslant 3$ for $I_n \leqslant 100$ A

$I_{f10}/I_n \geqslant 4$ for $I_n > 100$ A

$I_{f0\cdot1}\ I_n \leqslant 20\ (I_n/100)^{0\cdot25}$ for all current ratings

where

I_n = current rating of the fuse-link, and

I_{f10} and $I_{f0\cdot1}$ = pre-arcing currents corresponding to 10 seconds and 0·1 second respectively, expressed as mean values with the tolerances specified in **3.9** of IS : 9385 (Part 1)-1979*.

3.2.1 The term $(I_n/100)^{0\cdot25}$ is introduced to take account of the fact that the pre-arcing time-current characteristics for a range of fuse-links diverge as they approach the short-time region.

4. *K* FACTOR

4.1 *K* Factor is that which defines an overload characteristic to which the fuse-link may be repeatedly subjected under specified motor starting conditions, and other specified motor-operating overloads, without deterioration.

4.2 For the purpose of this specification, the value of *K* is chosen at 10 seconds. Unless otherwise stated by the fuse-link manufacturer, it is valid from 5 seconds to 60 seconds, for a frequency of starts, up to six per hour and for not more than two consecutive starts. For conditions different from those specified above, for example, where service conditions involve inching, plugging or more frequent starts, the manufacturer should be consulted.

4.3 The overload characteristic is obtained by multiplying the current on the pre-arcing characteristic by *K* (less than unity).

*Specification for high voltage fuses: Part 1 Current limiting fuses.

5. WITHSTAND REQUIREMENTS

5.1 The performance of a fuse-link for motor circuit applications is in general determined by the following criteria:

a) To withstand without deterioration, starting pulses in rapid succession due, for example, to abnormal service conditions, such as those occurring during commissioning of the equipment; and

b) To withstand without deterioration a large number of motor starts in normal service conditions.

5.2 This standard therefore specifies two sequences of tests representative of these conditions: 100 cycles corresponding to abnormal service conditions; 2 000 cycles corresponding to normal service conditions. It is expected that a fuse-link which passes these tests will have a good behaviour during a satisfactory life duration.

6. WITHSTAND TESTS

6.0 The withstand tests are type tests. Both test sequences shall be carried out on the same fuse-link.

6.1 The fuse-link shall be tested under the same test conditions as specified in **6.4.1.2** of IS : 9385 (Part 1)-1979*.

The values of test currents shall be KI_{f10} for pulses simulating the motor starting pulses and $KI_{f10}/^{6}$ for periods simulating the normal motor running, I_{f10} being the pre-arcing current at 10 seconds. The tolerance on both values shall be $+\,{}^{10}_{0}$ percent.

The duration of individual pulses shall be 10 seconds. The tolerance on the 10 second periods, both pulses and off periods, shall be ± 0·5 seconds.

Tests shall be made at any convenient voltage and at a frequency ranging from 48 Hz to 62 Hz.

6.1.1 *Test Sequence* 1 — This test sequence shall comprise 100 cycles of 1 h as follows:

a) A current, KI_{f10}, for 10 seconds;

b) An off period of 10 seconds;

c) A current, KI_{f10}, for 10 seconds;

d) A current, $KI_{f10}/^{6}$ for 3 560 seconds; and

e) An off period of 10 seconds.

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*Specification for high voltage fuses: Part 1 Current limiting fuses.

6.1.2 *Test Sequence* 2 — This test sequence shall comprise 2 000 cycles of 10 minutes as follows:

a) A current, KI_{f10}, for 10 seconds;

b) A current, $KI_{f10}/6$, for 290 seconds; and

c) An off period of 300 seconds.

These test sequences are illustrated in Fig. 1.

6.2 Interpretation of the Test Results

6.2.1 After each test sequence is completed, the fuse-link shall be allowed to cool. After cooling, there shall have been no significant change in its characteristics.

NOTE 1 — A check need not be made until after completion of both test sequences.

NOTE 2 — Measurements to show that there is no significant difference in the values of resistance of the fuse-links before and after the test give an indication of conformity with this requirement. In case of doubt, a further method is to subject the fuse-link after cooling after test to the current KIf_{10} sustained for a sufficient time to cause the fuse to operate. The pre-arcing time should lie within the tolerances of the pre-arcing time-current characteristic as given in **3.9** of IS : 9385 (Part 1)-1979*.

NOTE 3 — If fuse-links form part of a homogeneous series as defined in items (e) and (f) of **6.5.3.1** of IS : 9385 (Part 1)-1979*, the maximum and minimum current ratings only need be tested.

6.2.2 If the same value of K is assigned to both maximum and minimum current ratings, then that value may also be deemed to apply to all intermediate current ratings within the homogeneous series. If different values of K are assigned to the maximum and minimum current ratings, then the K factors for intermediate ratings may be determined by linear interpolation; *see* Fig. 2.

6.2.3 If a manufacturer assigns a higher value of K for an intermediate rating than that resulting from interpolation, this assigned value shall be proved by tests for conformity to the requirements of this clause.

7. INFORMATION TO BE GIVEN TO THE USER

7.1 Although in principle any high-voltage fuse-link can be used to protect motor circuits, there are advantages in selecting a fuse-link specifically designed for this application.

7.2 For fuse-links intended to be used for motor circuit protection the manufacturer shall state the K factor which will indicate to the user the degree to which the fuse-link is capable of withstanding cyclic overloads without deterioration. It shall be stated if the K factor is related to the minimum or the mean pre-arching time-current characteristic.

*Specification for high voltage fuses: Part 1 Current limiting fuses.

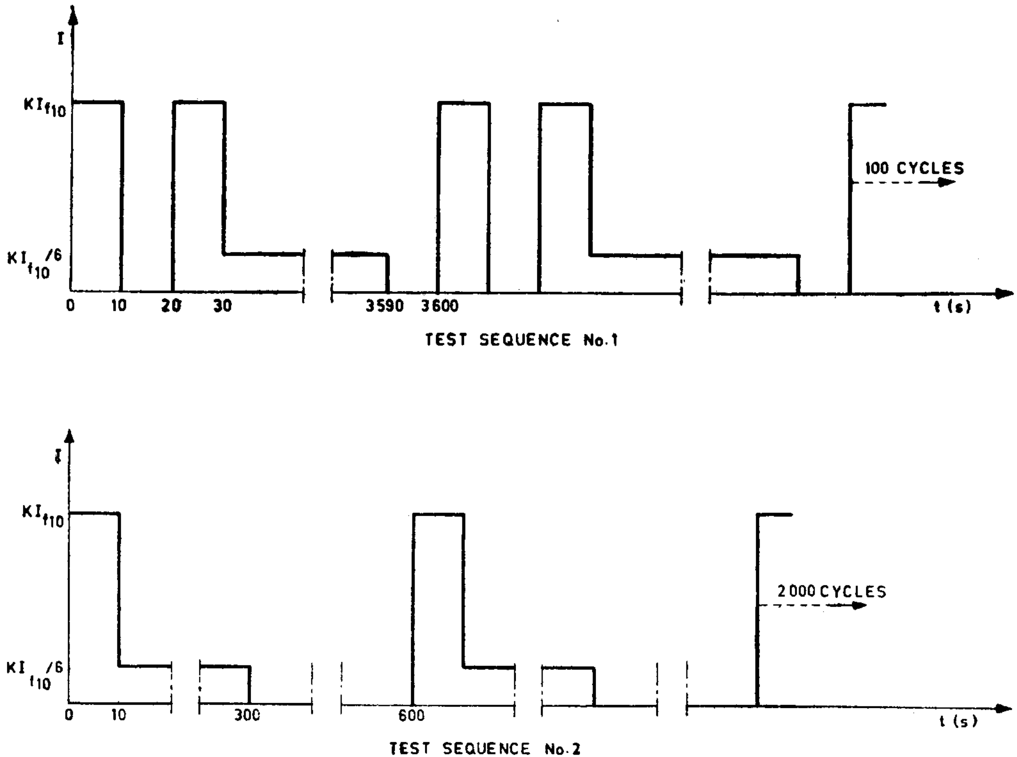


Fig. 1 Diagrams of the Test Sequences

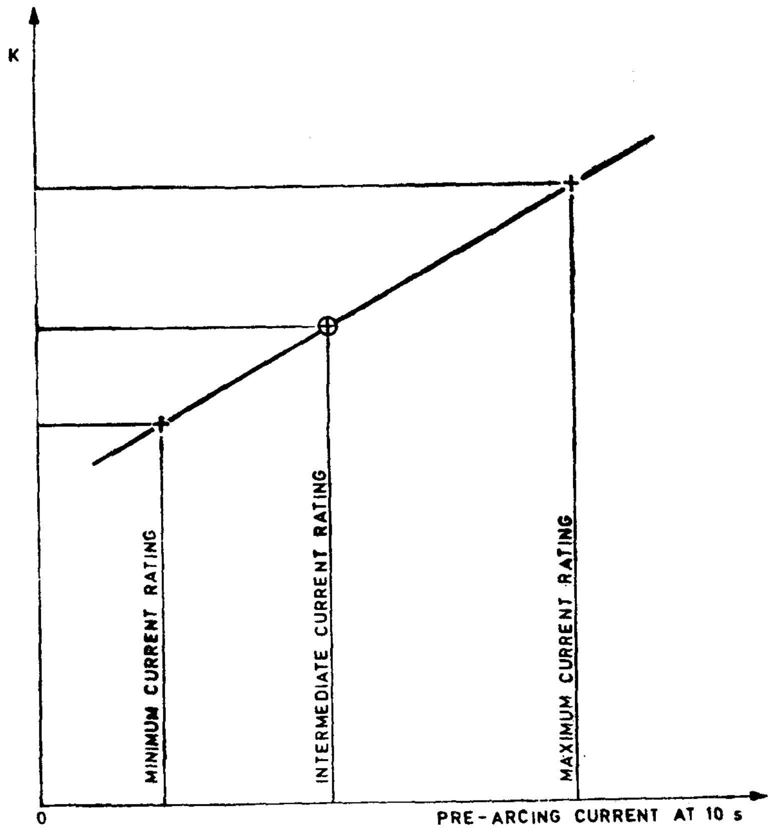


FIG. 2 DETERMINATION OF K FACTOR FOR FUSE-LINKS OF INTERMEDIATE RATING OF A HOMOGENEOUS SERIES

7.3 The pre-arcing time-current characteristic of the fuse-link, with current values multiplied by factor K, thus defines the boundary of the overload curve for a given number of motor starts per hour.

8. SELECTION OF FUSE-LINKS FOR MOTOR CIRCUIT APPLICATIONS AND CORRELATION OF FUSE-LINK CHARACTERISTICS WITH THOSE OF OTHER COMPONENTS OF THE CIRCUIT

8.1 Selection of Fuse-Links

8.1.1 The fuse-link is inserted in the motor circuit which the fuse-link is intended to protect. Some ratings of the fuse-links (for example,

rated voltage and rated breaking current) are therefore dependent on the system and others (for example, rated current) are dependent on the motor.

8.1.2 The ability to withstand repetitive starting conditions is an important factor. When selecting a fuse-link for a given motor circuit application, due regard should be paid to the *K* factor, which should be applied to the pre-arcing time-current characteristic of the fuse-link to take account of these starting conditions.

8.1.3 The usual concept of rated current, based upon the ability of a fuse-link to carry a given current continuously without exceeding a specified temperature rise, is usually of secondary importance where the motor is started direct-on-line. The fuse-link for such applications is normally chosen by reference to **8.1.1** and **8.1.2**.

However, it should be verified that the rated current of the fuse-link exceeds the running current of the motor in the service conditions by an amount sufficient to take account of the effects of the temperature of the surrounding air when the fuse-links are enclosed in starting motor control equipment.

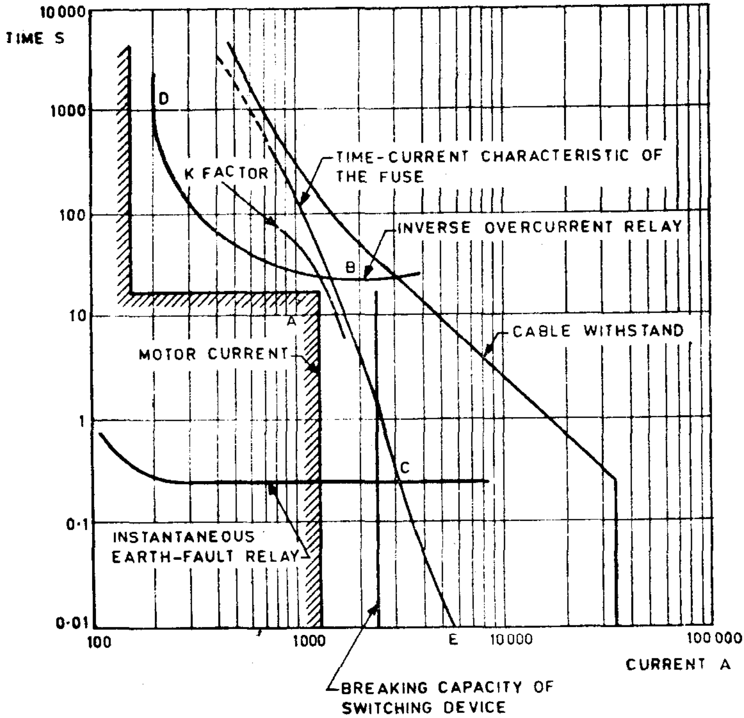
8.1.4 Where assisted starting is used and thereby starting currents are reduced, the above method of selection is generally applicable, but allowance may have to be made for the high transient currents which, with some methods of starting, flew during transition from one connection to the succeeding connection. Further, since assisted starting in general allows the use of fuse-links of lower current-rating, the temperature rise under running conditions is likely to be of primary importance.

8.2 Co-ordination with Other Circuit Components

8.2.1 Figure 3, illustrates a typical motor circuit application involving a motor, relay or relays (providing one or more of the following: inverse overcurrent protection, instantaneous overcurrent protection, instantaneous earth fault protection) contactor or other mechanical switching device, the cable and the fuse-link itself.

8.2.2 The motor will be chosen for its particular duty, thus fixing the values of the full load current and the starting current. The duration and frequency of the starts will also be fixed. The characteristic of the associated inverse overcurrent relay will then be chosen to give adequate thermal protection to the motor. The switching device is selected in conjunction with the fuse-link to co-ordinate with the already selected motor. Selection shall be done keeping in view, in particular the following factors:

a) The pre-arcing time-current characteristic of the fuse-link, when multiplied by the appropriate *K* factor, should lie to the right of the motor starting current at point *A*.



NOTE — For simplicity, only mean characteristics are shown. In practice, manufacturing tolerances and the variations between the 'cold' and 'hot' characteristics of the various components of the circuit should be taken into account.

FIG. 3 CHARACTERISTICS RELATING TO THE PROTECTION OF A MOTOR CIRCUIT

b) The mechanical switching device should be capable of withstanding the conditions defined by the combined operating characteristic DBCE.

c) The rated current of the fuse-link should be chosen such that when the fuse-link is mounted in its service position it is capable of carrying continuously the running current of the motor without overheating. This is of particular importance where assisted starting is used.

d) The current corresponding to the point of intersection *B* of the curves of the fuse-link and the overcurrent relay should be less than the breaking capacity of the mechanical switching device.

e) The minimum breaking current of the fuse-link should not exceed the minimum takeover current.

f) In the event of instantaneous protection being provided, the take-over point will move from *B* to *C*. Due regard should be paid to the possibility that the mechnical switching device might open at a current greater than its rated breaking current.

g) The cut-off current of the fuse-link at the maximum fault current of the system should not exceed the through-fault current withstand of the mechanical switching device for the operating time of the fuse, typically, one half cycle or less.

h) It is desirable that the minimum breaking current of the fuse-link should be as low as possible and preferably should be at least as low as the starting current of the motor [*see also* **2.4.1.2** of IS : 9385 (Part 3)-1980*].

j) As shown in Fig. 3, the whole of the withstand curve of the cable should lie to the right of the operating characteristic DBCE. Where high ratings of fuse-link are necessary due to the nature of the motor starting duty (for example, long starting times and frequent starts), the section BCE moves to the right and may necessitate an appropriate increase of cable size.

*Specification for high voltage fuses: Part 3 Application guide for high voltage fuses.

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